International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 7, Issue 1, Feb 2017, 23-34

THEORETICAL PERFORMANCE ANALYSIS OF OCTAGON CONFIGURATION AS COOLING MEDIA IN DIRECT EVAPORATIVE COOLING

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ABSTRACT

The present paper illustrates the performance enhancement technique of direct evaporative cooling based on previous research followed by development of octagonal cooling media for better saturation effectiveness. The heat exchange by cooling media for different configurations and material is studied. The influence of inlet air temperature, humidity, mass flow rate of air and supply air temperature has been discussed by using octagon-cooling media. It is evident that the octagon cooling media is more efficient than hexagonal cooling media for hot and dry climate in central India. Additionally, Octagon cooling media provides higher mass flow rate of supply air than hexagonal cooling media for same input of air. The comparison between hexagonal and octagonal cooling media shows that saturation efficiency is 93.6% for octagonal cooling media made of Aspen fibre at 40.5 ˚C DBT, whereas cooling capacity is 47769.81 Watt that is more than for the former. When the thickness of hexagonal and octagonal cooling media kept same then saturation efficiency decreases with increase in cooling capacity.

KEYWORDS: Direct Evaporative Cooling, New Cooling Media, Increase Saturation Efficiency, Configuration & Material

Nomenclature:

C_{pa}– *Specific heat of dry air in (J/KgK),*

C_{pu}– *Specific heat of humid air in (J/KgK),*

C_{pv}– *Specific heat of vapour in (J/KgK),*

v – *Kinematic viscosity in (m^2/s),*

ρ – *Density of air in (Kg/m^3),*

ε – *Effectiveness of cooling media,*

ω_a– *Humidity ratio in (kg of vapour/kg of dry air),*

K– *Thermal conductivity of air in (W/mK),*

Pr – *Prandtl number, dimensionless number,*

Re – *Reynolds number, dimensionless number,*

Nu– *Nusselt number, dimensionless,*

h_c– *convective heat transfer coefficient in (W/m^2K),*

m_a– *Mass flow rate of air in (kg/s),*

A – *Wetted surface area in (m^2),*

V_p – *volume occupied by the wetted media in (m^3),*

Original Article

***lc* – characteristics length of cooling media in (m),**

***l* – Thickness of cooling media in (m),**

T_1 – inlet dry bulb temperature of air in (˚C),

T_2 – supply air temperature of air in (˚C),

T_{wbt}– wet bulb temperature of outside air (˚C).

Acronyms

DEC – Direct Evaporative Cooling

TSEC–Two Stage Evaporative Cooler

DBT–Dry Bulb Temperature

WBT– Wet Bulb Temperature

RH–Relative Humidity

Received: Dec 06, 2016; **Accepted:** Jan 10, 2017; **Published:** Jan 13, 2017; **Paper Id.:** IJMPERDFEB20173

INTRODUCTION

At an early stage of air conditioning system, the direct evaporative cooling method played a significant role. The DEC is simplest, oldest and most common form of evaporative air conditioning technique. However, the arrival of the conventional air conditioning system for air conditioning has limited the use of direct evaporative cooling technique. Recently, this direct evaporative cooling technique have gained some momentum due to the environmental concern leading to ozone layer depletion and global warming, additionally it consumes more energy. On the contrary, direct evaporative cooling system is energy efficient and uses water as the working fluid. It is environmental friendly and has low maintenance cost, minimum manufacturing cost and easy installation. In view of the rapid concerns on above mentioned global environment and energy crisis issues, professionals and researchers in the field of air conditioning are creating more efforts to develop energy efficient evaporative cooling technologies and alternative of conventional air conditioning. Evaporative cooling is a process of the elimination of sensible heat from air and an equivalent addition of latent heat in the form of water vapour. The evaporative cooling process is categorized into three ways namely direct, indirect and indirect-direct evaporative cooling. The direct evaporative cooling process is best suited in dry climate (i.e. low humidity and higher ambient temperature) such as in central Indian climate. Generally, the air conditioning is done by using conventional air conditioning systems in summer and adversely, it increases the emission of green house gases. Direct Evaporative cooling is an energy efficient and environmental friendly method for air conditioning in hot and dry regions. The demand of Indian population varying according to change in climate throughout the year. Gilani et. al. (2014) classified the principle of evaporative cooling system into three major groups, the direct (DEC), indirect (IEC) and indirect/direct evaporative cooling technique. Watt (1997) showed the application of direct evaporative cooling technique in residential and commercial buildings, particularly in hot and dry region and suggested that it is impractical to achieve 100% saturation efficiency of DEC.

A large number of analysis has carried out on DEC system. Navon et.al.[1994] showed that the direct-indirect evaporative cooling method provides a better thermal comfort in more humid climate.

Dai and Sumathy (2002) obtained minimum air temperature and higher relative humidity by the use of honeycomb paper as packing materials. The honeycomb paper is compact in size and low in weight.

Anyanwu (2004) showed that,, the cooler storage chamber temperature depression from ambient air temperature varied over 0.1–12°C when ambient air temperatures varied over 22–38°C, while the gap between cooling media is filled by coconut fibre.

Hisham et al. (2004) evaluated indirect evaporative cooling system followed by a direct evaporative cooling (IDEC) unit at ambient air temperature higher than 45 ˚C experimentally. it used evaporative surface area of cooling media material which is $420m^2/m^3$ for high-density polythene in direct evaporative cooling unit. They concluded that the IEC/DEC effectiveness was higher than individual effectiveness of DEC and IEC and it was performed below wet bulb temperature.

Camargo et al. (2005) developed a mathematical model and presents experimental results for direct evaporative cooling system. They utilized an evaporative surface area $370m^2/m^3$ with the average pressure drop through the cooling media, which was about 25 Pa for cellulose material and study, showed that the higher effectiveness achieved at high dry bulb temperature and low wind speed.

Dilip (2007) examined the two-stage evaporative cooler for availability of short-term storage of fruits and vegetables. It showed that, the supply of indoor air temperature and relative humidity at two-stage evaporative cooler approximately 25°C and 92%, respectively.

Yonggao et.al.(2007) showed that, the liquid desiccant evaporative cooling provided suitable humidity of the supplied air. The liquid desiccant such as Licl–H_2O can be drawn from non-conventional heat sources such as solar energy as well as industrial waste heat at temperatures between 60 and 80°C.

Hindoliya et.al.(2010) studied the indirect-direct evaporative cooling technique for composite climate of India and the paper proposed a multistage evaporative cooling system for diverse climate condition.

Fouda (2011) developed and investigated mathematical model for direct evaporative cooling system. It shows the influence of cooling media thickness on the saturation efficiency at various inlet air velocities. Consequently, saturation efficiency is improved as per increase in thickness of cooling media, which is attributed to larger heat transfer area between water and inlet air.

Manuwa et. al (2012) Investigated different material and shape of cooling media, such as jute, latex foam, charcoal and wood shavings for considered respectively hexagonal and square cross-sections. In showed that the hexagonal shape cooler was found to be more efficient than the square shape and the saturation efficiency for hexagonal cooler was 93.5% (jute), 91.4% (latex foam), 91.3% (charcoal) and 91.9% (wood shavings). The maximum temperature drop observed 6.4 (jute media), 4.9 (latex foam media), 5.2 (charcoal media) and 3.6 ˚C (wood shavings).

Kulkarni et. al. (2013) investigated the three different geometry of cooling media with four different material. It results that, the hexagonal type cooling media geometry with aspen fiber performs better than other two cooling media as well as other comparative material in terms of saturation efficiency. That was because of the larger wetted surface area

than other comparative geometry and material of cooling media.

Gilani et.al. (2014) showed that, the direct evaporative cooling technique is used to provide low thermal comfort condition at higher outdoor air temperature and RH respectively. Whereas, it also found that, the low quantity of heat is absorbed by cooling media at high RH of ambient air.

Al-fahed et.al. (2014) investigated the pottery evaporative cooling system at inlet air temperature of 40°C–48°C for different airflow rates from 300 to 1,300 m^3/h. Which showed that, for all arrangements, the staggered case at 300 m^3/h, the air temperature dropped 6.5°C (5-cm gap) and 11°C(1-cm gap), and at a high airflow rate, both aligned and staggered arrangements showed an air temperature drop of 4°C.

The researchers are focused on the enhancement of saturation efficiency by increasing wetted surface area of cooling media. The enhancement is achieved by increasing heat transfer area between water and air in case of direct evaporative cooling system.

The objective of the present study is to improve the saturation efficiency of direct evaporative cooling system for dry and hot climate of India. This research work presents comparative theoretical analysis to improve saturation efficiency by using an octagon cooling media, which increases wetted surface area of direct evaporative cooling system.

PERFORMANCE ANALYSIS OF HEXAGONAL COOLING MEDIA WITH DIFFERENT MATERIAL DERIVED FROM PREVIOUS DEVELOPMENT OF COOLING GEOMETRY

The performance of direct evaporative cooling system has been theoretically analysed in terms of temperature drop and saturation efficiency[14]. The performance parameter is listed in table 1.

Table 1: Comparative Performance of Hexagonal Cooling Media with Different Material[14]

Performance Parameter	Inlet Dry Bulb Temperature	Inlet Wet Bulb Temperature	Supply Air Temperature	Wetted Surface Area	Air Velocity	Mass Flow Rate of Air	Saturation Efficiency	Temperature Drop
	(°C)	(°C)	(°C)	(m^2)	(m/s)	(Kg/s)	(%)	(°C)
Cellulose	39.9	25.59	28.14	42.6	0.75	0.865	82.26	11.76
Cellulose	39.9	25.59	29.17	42.6	2.25	2.595	75.05	10.73
Corrugated Paper	39.9	25.59	27.78	46	0.75	0.865	84.76	12.12
Corrugated Paper	39.9	25.59	28.76	46	2.25	2.595	77.92	11.14
High Density Polythene	39.9	25.59	27.57	48.4	0.75	0.865	86.24	12.33
High Density Polythene	39.9	25.59	28.51	48.4	2.25	2.595	79.65	11.39
Aspen	39.9	25.59	26.88	58	0.75	0.865	91.04	13.02
Aspen	39.9	25.59	27.66	58	2.25	2.595	85.58	12.24

The supplied air temperature is 26.88 °C and 27.66°C at inlet velocity of 0.75m/s and 2.25 m/s, respectively. It has been observed that, hexagonal cooling media has maximum saturation efficiency by using aspen fiber at 0.75 m/s inlet air velocity. It shows that, the large wetted surface area gives maximum temperature drop because of increase in heat transfer area between water and air.

Performance analysis of direct evaporative cooling system with different material used as cooling media is shown in Table 2. Investigation of different material such as aspen fibers, khus fibers, coconut fibers and palash fiber shows that the saturation efficiency and temperature drop capacity of palash fiber is higher than the other materials used as cooling media[12]. Theoretical & experimental analysis of jute fiber shows its saturation efficiency is comparable to other material.

However, this cooling media does not provide enough temperature drops. Hence, it is suitable for low outdoor air temperature[15, 13]. Experimentally it has been analysed that Honeycomb paper recommended as a good humidifier and the feed water temperature is always less than the inlet air temperature approximately by 4°C[5].

Table 2: Comparative Performance Analysis of DEC with Different Material of Cooling Media

Ref.	Performance Parameter	Inlet Dry Bulb Temperature	Inlet Wet Bulb Temperature	Supply air Temperature	Wetted Surface Area	Air velocity	Mass Flow Rate of Air	Saturation Efficiency	Temperature Drop
		(°C)	(°C)	(°C)	(m^2)	(m/s)	(Kg/s)	(%)	(°C)
12	Aspen fibers	42.25	24.42	28.81	2.991	N/A	0.029	75.37	13.44
12	Khusfibers	42.82	24.22	29.12	1.248	N/A	0.029	73.66	13.70
12	Coconut fibers	43.12	24.17	28.22	2.091	N/A	0.029	78.60	14.89
12	Palashfibers	43.5	24.15	27.26	1.489	N/A	0.029	83.89	16.23
15	Jute fiber	39.9	25.59	29.4	8.765	2.25	0.295	73.40	10.50
15	Jute fiber	39.9	25.59	27.4	10.46	3.75	0.295	87.40	12.50
13	Jute fiber	34.5	21.6	25.59	2.463	N/A	0.400	69.00	8.91
5	Honeycomb paper	35	23.9	26	N/A	N/A	N/A	81.08	9

Performance analysis of different material and geometry of cooling media shows that the Palash fiber is better cooling media than other as it has higher saturation efficiency with maximum temperature drop[12]. Furthermore, it has shows that the hexagonal cooling media is more efficient than cylindrical and ordinary rectangular cooling media[14].

The above literature has shown the direct evaporative cooling system does not achieved 100% saturation effectiveness. Therefore, designing of octagon geometry for cooling media is to enhance the saturation efficiency and cooling capacity.

PLACE OF INVESTIGATE

An investigation was carried out from the year 2014 to 2016 Average of daily minimum and maximum temperature of Bhopal, in India [23°15′N 77°25′E]. Table 3 shows Average of daily minimum and maximum temperatures in Bhopal for the period of three years.

Table 3: Average Daily Minimum and Maximum Temperatures at Bhopal, in India (2014-2016)

YEAR	2014			2015			2016		
MONTH	ADMAXT (˚C)	ADMINT (˚C)	RH (%)	ADMAXT (˚C)	ADMINT (˚C)	RH (%)	ADMAXT (˚C)	ADMINT (˚C)	RH (%)
JANUARY	23.30	12.30	75.37	21.50	10.40	76.03	26.88	11.89	56.24
FEBRUARY	26.40	12.50	64.46	29.10	14.10	53.30	29.57	13.85	46.15
MARCH	32.60	17.40	48.84	30.63	17.40	50.35	35.39	19.05	33.62
APRIL	38.60	22.30	27.93	37.52	22.84	32.58	40.04	23.90	22.17
MAY	40.50	26.10	29.03	42.21	27.17	25.30	41.75	27.25	31.53
JUNE	40.60	28.00	42.12	36.98	25.92	58.20	38.81	26.92	54.43
JULY	31.90	24.70	78.28	30.61	24.30	75.98	–	–	–
AUGUST	30.48	23.72	82.17	29.85	23.39	85.33	–	–	–
SEPTEMBER	31.50	22.86	77.35	33.07	22.75	67.30	–	–	–
OCTOBER	32.74	19.73	61.11	34.49	20.38	50.93	–	–	–
NOVEMBER	30.60	15.76	55.43	31.37	17.57	53.46	–	–	–
DECEMBER	24.44	10.49	60.00	26.59	11.16	46.76	–	–	–

ADMAXT = Average Daily Maximum Temperature in Degree Celsius

ADMINT = Average Daily Minimum Temperature in Degree Celsius

RH = Average Relative Humidity in Percentage

= Not Available

Source: Meteorological Centre, Arera Hills, Jail road, Bhopal Madhya Pradesh, India-462011

NEW GEOMETRY OF COOLING MEDIA AND ITS THERMODYNAMIC ANALYSIS

The recorded environmental data of Bhopal from January 2014 to June 2016 is categorized into five sections that are month and year, average maximum temperature, relative humidity, wet bulb temperature and specific humidity as shown in table 3. Therefore, the most appropriate data of average maximum temperature and RH are used for the present analysis as listed in table 4.

Table 4: Inlet Conditions of the Two Cooling Media

Month & Year	ADMAXT /DBT(˚C)	RH (%)	WBT(˚C)	ω_a (kg/kg da)
May-14	40.5	29.03	25.1	0.01381
May-15	42.21	25.3	25.2	0.01316
May-16	41.75	31.53	26.8	0.01608
Psychrometrics properties of air (WBT and ω_a) are calculated on the basis of DBT and RH.				

According to previous research showed that the large volume of cooling media configuration increases wetted surface area of cooling media at same packing density of material. Volume occupied by octagon cooling media is greater than hexagonal cooling media. Therefore, inlet flow area and mass flow rate of octagon cooling media is increased. Hence, this research shows the octagon cooling media enhanced the cooling capacity of direct evaporative cooling system than prior hexagonal cooling media.

Figure 1, shows the dimensions of octagon cooling media and path of air flow. Dimensions and evaporative surface area of hexagonal cooling media has been taken from earlier development of cooling media with aspen fiber. It shows more saturation efficiency than other comparative material and cooling media configuration [14]. Therefore, aspen fiber has been considered for analysis of octagon cooling media.

Table 5: Specification of Octagon & Hexagonal Cooling Media Made by Aspen Fiber

Thickness of Cooling Medias	Inlet Flow Area	Outlet Flow Area	Volume of the Media	Evaporative Surface Area of Cooling Media	Wetted Surface Area
(m)	(m^2)	(m^2)	(m^3)	(m^2/m^3)	(m^2)
Octagon Cooling Media					
0.18	1.44	0.72	0.1955	503.7	98.47
0.15	1.44	0.8448	0.1709	503.7	86.08
Hexagonal Cooling Media[15]					
0.15	1.08	0.4565	0.1152	503.7	58.02

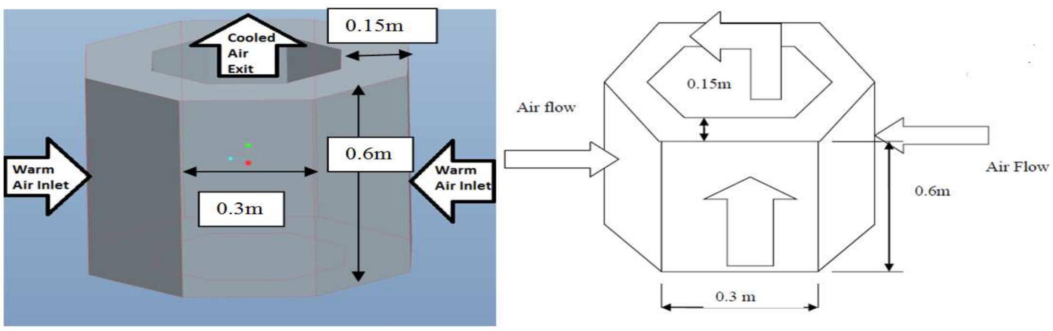

Figure 1: Schematic Representation of Octagon Cooling Media and Hexagonal Cooling Media

Density, kinematic viscosity, Specific Heat of Air is for altitude at Bhopal are as follows[14]:

ρ=1.068 Kg/m^3, C_{pa}= 1007 J/KgK, C_{pv} =1037 J/KgK) ν=17.95X10^{-6}, K=0.02662 W/mK, Pr=0.7255

Thermodynamic modelling of the cooling media are as follows

Specific heat of moist air can be calculate by following equation[2]

$$C_{pu} = C_{pa} - \omega_a C_{pv} \tag{1}$$

Effectiveness of cooling media can be calculate from the equation[4]

$$\varepsilon = 1 - exp\left\{-\frac{h_c A}{m_a C_{pu}}\right\} \tag{2}$$

$$\varepsilon = \frac{T_1 - T_2}{T_1 - T_{wbt}}. \tag{3}$$

Heat transfer coefficient can be calculate from this equation[7]

$$Nu = 0.01\left(\frac{l_c}{l}\right)^{0.12} Re^{0.8} pr^{0.33} \tag{4}$$

Thickness and characteristic length of cooling media is denoted by *l* and *lc*, respectively.

Characteristic length is give by

$$l_c = \frac{V_p}{A} \tag{5}$$

Where A is the total wetted area and V_p is the volume occupied by the wetted media.

Cooling capacity of DEC can be calculated from below equation[14]

$$Q = m_a * c_{pa} * (T_1 - T_2) \tag{6}$$

Specific humidity of air can be calculated from following equation[2]

$$\omega = 0.622\left(\frac{P_{V1}}{P - P_{V1}}\right) \tag{7}$$

Where, P & P_{v1} is atmospheric pressure and saturation pressure of water vapour respectively.

Water consumption is given by[12]

$$m_w = m_a * (\omega_1 - \omega_2) \tag{8}$$

Where ω_1 and ω_2 is specific humidity of inlet and outlet air of the cooling pad

RESULTS AND DISCUSSIONS

Octagon cooling media improved the performance of direct evaporative cooling system than the hexagonal cooling media in terms cooling capacity. Octagon cooling media achieved the supply air that is closed to the wet bulb temperature when cooling media thickness is 0.18m.

Table 6: Performance Parameter of Different Geometrical Configuration (l=0.18m)

Inlet Velocity of Air	Outlet Velocity of Air	Average Velocity	Volume Flow Rate	Mass Flow Rate of Air	heat Transfer Coefficient	Saturation Efficiency	Supply Air Temperature	Cooling Capacity	Water Consumption
(m/s)	(m/s)	(m/s)	(m^3/s)	(Kg/s)	(W/m^2K)	(%)	(˚C)	(J/s)/Watt	(Litre/Min)
	DBT 40.5˚C & RH 29.03% (Case-I)								
	Performance parameter of octagon cooling media (l=0.18m)								
0.75	1.5	1.125	1.08	1.153	34.035	93.6	26.0	16741.60	0.413696
1.25	2.5	1.875	1.80	1.922	51.217	91.7	26.3	27324.35	0.674622
1.75	3.5	2.625	2.52	2.691	67.037	90.2	26.5	37646.12	0.930009
2.25	4.5	3.375	3.24	3.46	81.966	89.0	26.7	47769.81	1.179168
	DBT 40.5˚C & RH 29.03% (Case-I)								
	Performance parameter of octagon cooling media (l=0.15m)								
0.75	1.5	1.125	1.08	1.153	34.035	89.5	26.71	16009.15	0.301539
1.25	2.5	1.875	1.80	1.922	51.217	87.0	27.09	25945.63	0.489703
1.75	3.5	2.625	2.52	2.691	67.037	85.2	27.38	35552.74	0.672327
2.25	4.5	3.375	3.24	3.46	81.966	83.7	27.60	44929.10	0.850122
	DBT 40.5˚C & RH 29.03% (Case-I)								
	Performance parameter of hexagonal cooling media								
0.75	1.77	1.26	0.810	0.865	37.162	91.1	26.48	12213.98	0.301539
1.25	2.96	2.1	1.350	1.442	55.922	88.7	26.84	19831.47	0.4897032
1.75	4.14	2.95	1.890	2.019	73.395	87.0	27.10	27248.73	0.672327
2.25	5.32	3.79	2.430	2.595	89.685	85.7	27.31	34469.76	0.850122

Table 6 shows the influence of inlet velocity of air, outlet velocity of air, volume flow rate, heat transfer coefficient, saturation efficiency, water consumption rate and cooling capacity throughout the adiabatic process in octagon and hexagonal cooling media.

The main advantages of octagon cooling media drawn from this result are as following:

- The new geometry of cooling media is superior to hexagonal cooling media. The octagon cooling media gives higher cooling capacity, mass flow rate at same inlet velocity of air.
- The saturation efficiency is decreased with increase in inlet velocity of air and mass flow rate of air. Whereas, octagon-cooling media indicated that during same inlet condition of air, the water consumption rate, cooling capacity and mass flow rate of air increased than hexagonal cooling media.
- Saturation efficiency of octagon cooling media is increased with cooling media thickness 0.18m and it has decreased with cooling media thickness 0.15m. However, cooling capacity is increased in both the above conditions as compare to hexagonal cooling media.
- The octagon and hexagonal cooling media gives saturation efficiency of 93.6% and 91.1% respectively while cooling capacity is 16741.60 J/s and 12213.98 J/s respectively at same atmospheric condition. Hence, octagon-cooling media achieved higher cooling capacity as compare to hexagonal cooling media.

The performance of octagon cooling media over hexagonal cooling media is shown in figure 3. Here, it is found that the saturation efficiency is given by octagon cooling media (93.6%) which is more than the hexagonal cooling media (91.1%) for the same ambient condition.

It appears that the saturation efficiency varies slightly and cooling capacity becomes maximum for same inlet velocity when configuration of cooling media changed from hexagon to octagon. Therefore, octagon-cooling media gives more saturation efficiency than hexagonal cooling media at same inlet velocity of air and atmospheric condition. Hence, octagon configuration is more effective than hexagon. Figure 3 shows the saturation efficiency deviation by using octagonal and hexagonal geometry with aspen media in different atmospheric condition.

Two-stage evaporative cooler (TSEC) supply air temperature is 25°C and RH 92% when outdoor condition is dry bulb temperature 41°C & RH 30%. Similarly octagon cooling media supply air temperature is 26 °C & RH 93.1% when outdoor condition is dry bulb temperature 40.5 °C % RH 29.03%. It shows that the octagonal cooling media achieved approximately TSEC supply air condition without taking any kind of special effort like double humidifier for decreasing indoor air temperature. Therefore, octagon media has better geometry for space cooling and short-term food preservation[7].

Graphical Comparison

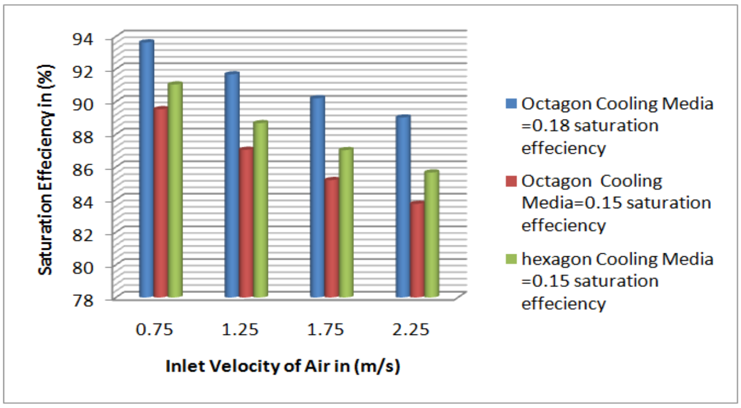

Figure 2: Saturation Efficiency vs. Inlet Velocity of Air

The saturation efficiency is decreased with increase in inlet velocity of air and mass flow rate of air. When the thickness of hexagonal and octagonal cooling media kept same then saturation efficiency decreases with increase in cooling capacity. In other words, cooling capacity is increases with decrease in saturation efficiency having same thickness of hexagonal as well as octagonal cooling media shown in figure 2 & 4.

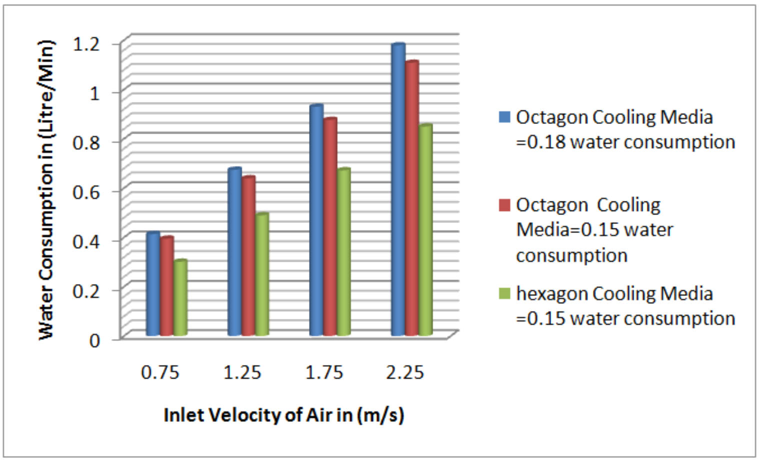

Figure 3: Water Consumption vs. Inlet Velocity of Air

Water consumption rate, cooling capacity and mass flow rate of air increases in octagonal cooling media as compare to hexagonal cooling media having same cooling media thickness in both configuration as shown in figure 3.

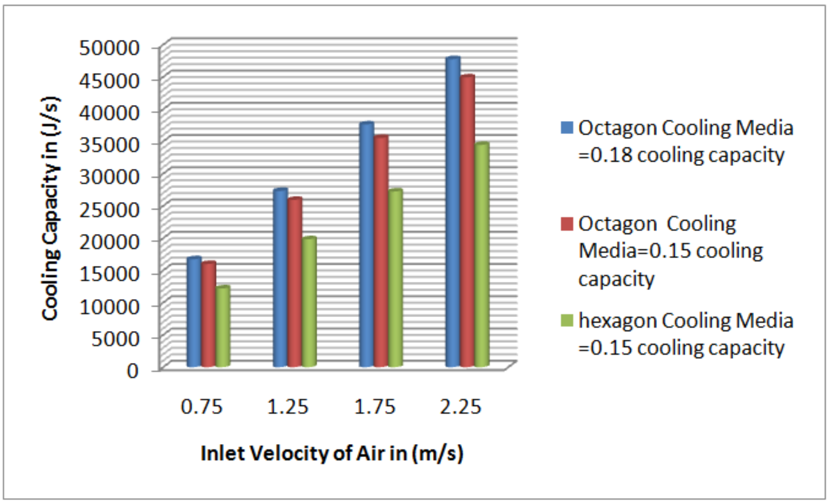

Figure 4: Cooling Capacity vs. Inlet Velocity of Air

The cooling capacity is increases with increased inlet velocity of air having thickness (0.18m & 0.15m) of octagonal cooling media and hexagonal cooling media thickness is 0.15m shown in figure 5. Therefore, the performance of octagonal cooling media using both the thickness is more as compare to hexagonal cooling media.

CONCLUSIONS

The conclusions made from this study are following:

- This paper concisely expressed earlier work to analyse the overall performance of direct evaporative cooling system in dwelling place located in hot and dry climate regions.
- The proposed cooling media performed higher cooling capacity than ref case at same inlet velocity and atmospheric condition of air.
- Octagon configuration is enhanced the saturation efficiency upto 3% than hexagonal configuration with thickness of cooling media 0.18m.
- Octagon-cooling media performed supply air condition approximately same as of TSEC.
- Octagon cooling media gives supply air temperature nearest to wet bulb temperature.
- Direct evaporative cooling does not achieved 100% saturation efficiency.
- Low level of human comfort in terms of high supply air RH is the main drawback of the direct evaporative cooling system.

ACKNOWLEDGMENTS

The authors are thankful for the support of the Maulana Azad National Institute of Technology, Bhopal.

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